by Mr. Henry Harden, C. E., and described the geological features of that part of the basin portrayed by the map.

Mr. Lesley also described the geological facts of most interest recently studied by Mr. Franklin Platt and Mr. John H. Harden, C. E., on Dunning's Creek, Bedford County, Pennsylvania, and compared the exhibition of the Fossil Ore beds of No. V (Clinton Group, Upper Silurian) with that of the same deposit at Frankstown, Danville and other points in Pennsylvania.

Mr. Price introduced the subject of a Geological Survey of Pennsylvania, which led to its discussion by Prof. Trego and other members present.

Prof. Chase placed on record, with explanatory remarks, four notes: 1, on Planeto-taxis; 2, on the rotation of the Sun and interasteroidal planets; 3, on the special planetary relations to the Sun-spot period; 4, on the relative velocity of light and gravity.

Pending nominations Nos. 715 to 728, and new nominations Nos. 729 to 732, were read.

And the meeting was adjourned.

ST. CLAIRSVILLE AND BEDFORD RAILROAD; AND DUNNING'S CREEK FOSSIL IRON ORE.

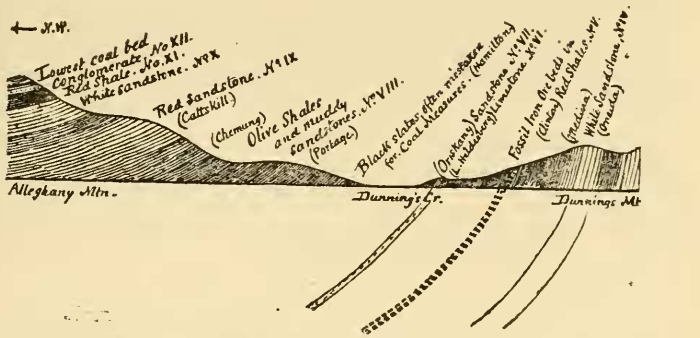
By Professor J. P. Lesley.

(*Read before the American Philosophical Society, March* 7, 1873.)

Mr. Franklin Platt has recently made for me a topographical and geological survey and sketch-map of some valuable deposits of iron ore in Bedford county, Pennsylvania; and Mr. John W. Harden a special study of the same with a view to the best way and probable expense of mining the ores. I have had the map ithographed, as an illustration of the characteristic features of the outcrop of the Upper Silurian rocks, which borders on the east the Bituminous Coal Field of Western Pennsylvania

In front of the Allegheny Mountains, which runs for a hundred miles in nearly a straight (N. E. and S. W.) line from Muncy to opposite Bedford, lies a long, narrow, straight, deep valley, about five miles wide, occupied successively by the West Branch Susquehanna, the Bald Eagle Creek, the Little Juniata, the south head of the Juniata river, and finally by Dunning's Creek, which flows southwest and joins the Raystown Juniata at Bedford.

A geological cross-section of this valley, taken almost anywhere, is something like this:—Fig. 1.



The only notable variations from the above cross-section occur at three far distant points: 1. At Muncy, where the fossil ore flattens and sweeps round the northeast anticlinal end of the Bald Eagle Mountain; 2. at Frankstown and Holidaysburg, where the fossil ore flattens and sweeps round the southwest end of Bald Eagle Mountain and the northeast end of Dunning's Mountain; 3. North of Bedford; where in a precisely similar style, the fossil ore beds, the red shales in which they lie embeded, the limestone formation (VI) over the red shale (V), and the Oriskany sandstone (VII) all flatten and sweep in concentric semi-circles round the southwest end of Dunning's Mountain, a ridge of rock extending from Holidaysburg to St. Clairsville, about 20 miles. This mountain opposite St. Clairsville makes a right angle and runs east several miles, and then makes another right angle, and resumes its south-southwest course, past Bedford, into Maryland.

The fossil ore beds follow its flank.

Where the mountain runs its regular course the fossil ore beds are steep (nearly vertical) and their outcrops lie high up on the mountain side.

But where the mountain makes its offset to the eastward the fossil ore beds (and other formations) lie flat, dip south at gentle angles, and their outcrops are far removed from the base of the mountain.

The region specially examined in this case sweeps round with the ore beds; having them steep on the mountain side at its north and northwest end—having them flat and away from the mountain (on Black Oak Ridge) in its middle portion—and having them again steep and up the mountain side, at its eastern and southern end. Geographically, it begins at St. Clairsville (its northwest end); extends three miles southward along the east slope of Black Oak Ridge; then half a mile eastward; and then three miles northeastward into Dutch corner. Its St. Clairsville end is ten miles from Bedford; its Dutch Corner or southeast end seven miles.

The surveyed line of the Bedford and Dunning's Creek Railroad passes

close to its southern boundary; and by this branch of the Huntingdon and Bedford line, its railroad distance from Huntingdon would be 57, and from Philadelphia 259 miles.

Should the B. & D. C. R. R. pass St. Clairsville and reach McKee's Gap (through Dunning's Mountain into Morrison's Cove) 17 miles north of St. Clairsville, the outlet of the ore would be, via Altoona, to Pittsburgh also.

I. Outcrops of Fossil Ore.—Three cross-sections, marked AB, AC, AD, on the map, show the geological structure along lines diverging west southwest and south, and the steepness or flatness of the ore beds.

Figs. 2, 3, 4. Representing these sections are reduced to a scale of 2 miles to the inch, in photolithographing them.

Fig. 2.

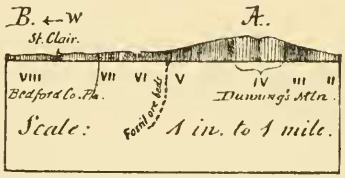


Fig. 3

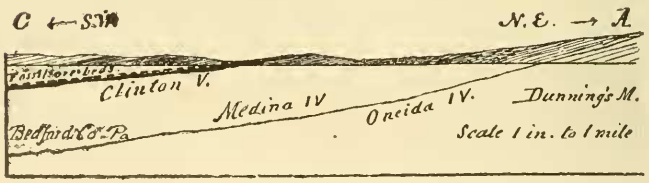
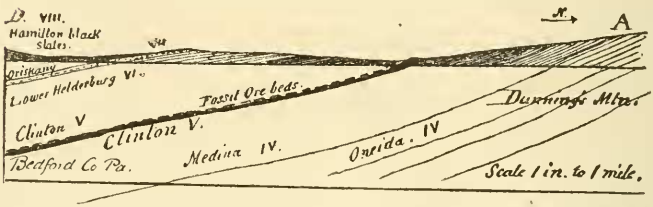


Fig. 4.



AB, Fig. 2, 8,000 feet long, passes through St. Clairsville and a gap in Black Oak Ridge, and shows the formations IV, V, VI, VII, and black slates of VIII, all in a vertical posture.

AC, Fig. 3, 15,000 feet long, shows the formations IV, V, VI, and VII flattened down, so as to spread the ore over the surface of the hill.

AD, Fig 4, 15,000 feet long, shows the same formations, with the ore dipping at an angle of about 20°.

There is a small sharply-pinched synclinal (trough) of limestone VI, between Black Oak Ridge and the foot of the mountain south of St. Clairsville. This Upper Silurian limestone basin is less than 150 yards across.

Black Oak Ridge is about 200 feet high above the brook at its foot. At its north end near St. Clairsville the Oriskany Sandstone VII forms its backbone; the black slates of VIII are there so much like coal-measure slates that the villagers of St. Clair explore them for coal beds; which of course do not exist. They are near the base of the Devonian.

At Weiset's house and southward the outcrop of the ore is at the bottom, or on the east slope of Black Oak Ridge. See local section, Fig. 5.

Figs. 5 and 6. Reduced to a scale of 200 yards to one inch.

Fig. 5.

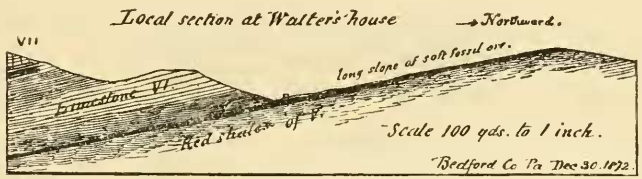
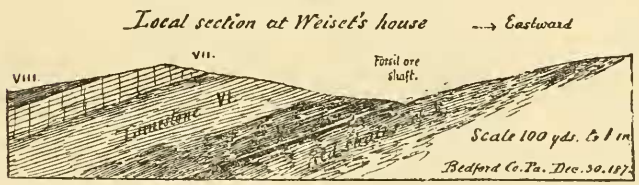


Fig. 6.



From Griffith's house eastward, the outcrop ore is on the summit of the ridge, and the bed spreads broadly down its gently-sloping back. See local section, Fig. 6.

From Walter's house, northeastward, the outcrop slips down the north or front slope of the hill, facing the mountain, the hill top being about 150 feet above the brook.

The Limestone Ridge (capped with sandstone) runs round south of the ore ridge, and is twice as high (300 feet).

As the sections are drawn to scale (horizontal and vertical the same) they explain themselves, and proceed to the description of the ore beds themselves.

II. The Fossil Ore Beds.—There are three ore beds in the red shale of V. They lie so close together that they can be quarried together where the dip is gentle, as at Walter's. But they lie so far apart that they cannot always be mined by one gangway where the dip is vertical or very steep.

The most northern openings in this range are 150 yards south of

Weiset's house, and just above the brook level. Three shafts on the three beds. Upper and middle fallen in. Lower bed 12 inches of ore. Slates in roof and floor. Dip of ore N. 55° W. 30° to 35°. General dip of formation 20°+. All three beds in 12 feet of shales.

Ore crop on the hill top 600 yards east of Griffith's, dipping gently S.W. say 6°. Ore crop on hill top, 400 yards E. 20° north of Sill's house; dip say 6°. Ore crop on road at foot of the hill, near the creek, 350 yards E. of Sill's house; dip say 5°. Shaft on hill top, midway between Sill's and Walter's, shows 41 inches of fossil ore in 12 feet of measures; dip say 5° to the south. See local section, Fig, 7.

FIG VII

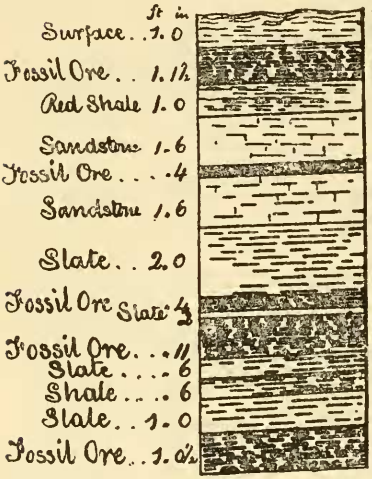


FIG 9

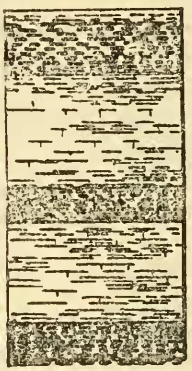


FIG 10

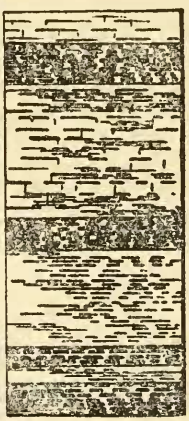
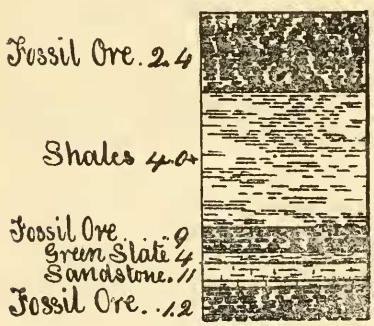


FIG 8



On Walter's place near the brook, this lowest bed has been mined for the furnace, 15 inches thick ; very fine ore.

The heaviest covering Mr. Walter has found lying upon the upper bed of ore, anywhere on the slope from brook to hill top between his farm and Griffith's, is 6 feet of olive slates. This is at the top of the hill up from the last named mining ground.

North of Walter's house, on the road, the above section gives 47 inches of ore, in 10 feet of space ; dip say 4° S. 70° East. See vertical section, Fig. 8.

About 900 yards east of the road, and on the north side of the ridge, a shaft on the outcrop shows 47 inches of ore in 10½ feet of measures ; dip say 8° S. 50° East. Fig. 9.

About 500 yards east of the last exposure, and also on the north slope of the ridge, 80 feet below its crest, the ore dips S. 30° E. 7° to 8°. Here the ore crop leaves the ridge and strikes across to the mountain side.

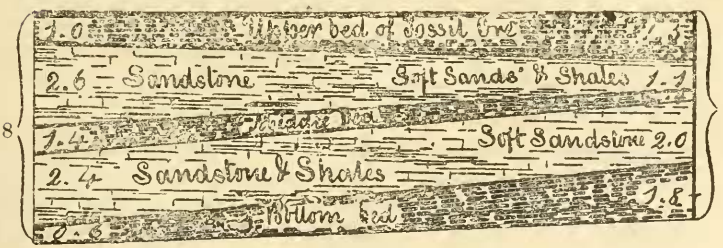
At the northeast end of Dutch Corner the next section shows 38 inches of ore in 10½ feet of measures ; dip of sandstone S. 30° W. 17°. Fig. 10.

The thickness of ore in each bed varies with every rod of outcrop, as may be seen from the above vertical sections.

The total thickness of ore in all three beds, on the contrary, scarcely varies at all. In other words, one can confidently count on a total thickness of between three and four feet of the ore in from ten to twelve feet of measures. Secondly, on always having at least one of the three beds of a good size. Thirdly, on always mining two of the beds in one gangway. One is always secure of at least two feet of good fossil ore, no matter where the beds are opened.

This regularity conjoined with irregularity is well illustrated in one of

Fig. 11



Kemble Iron Co Bedford Pa.

the two gangways of the Kemble Iron Company in the gap at Bedford. It inspires great confidence in the mining qualities of the formation all along Dunning's Mountain for twenty miles. The two connected sections,

Fig. 11, were got in the north gangway, one at 400 yards in, and the other at 475 yards.

III. Quality of Ore.—The three beds seem to preserve their three individually distinct and different characters.

The top bed is a hard fossiliferous ore.

The middle bed is hard, and almost a limestone.

The bottom bed is soft, rich in iron, and holds but little lime. It looks (theoretically) as if it had always been the water-bearing stratum, and has suffered therefore so complete a washing out that all its original shells have disappeared, and their places and forms been assumed by the oxide of iron. This, however, will be its state only to a certain depth below the present valley bottoms. It will then become a rocky calcareous ore, something like the middle bed. The same is true of it (and the other beds to a less extent) when mined down from the outcrop. They will lose in iron and gain in lime.

At Bloomsburg "soft ore" holding 85 per cent. perox. iron and only a trace of carbonate of lime, turns into "hard ore" holding 61 per cent. perox. iron and 33 per cent. carbonate of lime.

At Hopewell furnace "soft ore" of 78 per cent. perox. iron and a trace of carbonate of lime, becomes a "hard ore" of 55 per cent. perox. iron and 31 per cent. carbonate of lime.

A multitude of analyses show the soft ore to range in its peroxide of iron between 30 and 75 per cent. Where the dip is steep the breast of soft ore is of course short; where the dip is flat the breast of soft ore is very extensive—as between Griffith's and Walter's, and so on into Dutch Corner. Where the bed spreads as a surface-coating to a broad and gentle hillslope it is in its highest prime condition, both of richness and for cheap and abundant mining. It is here about a 50 per cent. ore; that is, it will allow of getting one ton of iron from two tons of ore, or practically two tons and a quarter. Prof. H. D. Rogers, who made a careful, special study of this important subject at Danville and Bloomsburg, concluded that when the hillside sloped 15° and the ore beds dipped into it 30° the softened part of the bed extended downwards about 40 yards, and he assumed this as the basis of his calculations of quality.

IV. Quantity of Ore.—*From St. Clairsville to Griffith's; steep dip.*—(*a.*) From opposite St. Clairsville to Weiset's the outcrop descends the mountain slope 3,200 yards to water level in the brook. Taking 40 yards as the depth of the soft ore, thickness (in 12 feet of measures) 40 inches (1 1-9 yard) of ore, and 2 tons to the cubic yard, we have 280,000 tons of soft ore; say one-half of this lies above brook water level.

(*b.*) *From Weiset's to Griffith's; dip growing less steep.*—Outcrop always from 25 to 35 feet above brook level, on east side of Black Oak Ridge, 1,900 yards. Soft ore say 50 yards down; tons 210,000; mostly below brook water level.

(*c.*) *From Griffith's to* (*shaft* 100 *yards east of road north of*) *Walter's;*

dip almost horizontal.—Top ore bed scarcely 3 or 4 feet under surface anywhere; ore beds thoroughly softened and enriched by dissolution of the shells; lowest bed very rich; distance 1,500 yards; breadth from brook up to hilltop 200 yards; total amount of soft ore above brook to be got by stripping, 400,000 tons; total of ore to be got by stripping or otherwise, 660,000 tons.

Note.—The deduction 660,000 to 400,000 is based on the fact that towards the bottom of the slope the covering shales get to be 10 or 12 feet thick (as in the old celler opposite Walter's house), and may be equally thick in other places. This will interfere only with the open quarry work, but not with underground mining.

(*d.*) South of the brook the beds descend beneath the country very flat and are softened doubtless to a great distance downward. If we assume 300 yards, we have thus, beneath water level, one million (1,000,000) tons of soft ore.

(*e.*) *From Walter's eastward.*—For the first 1,300 yards north eastward. At 800 yards the crop has got down 25 feet below the crest of the ridge on its north face; at 1,300 yards 100 feet. Most of the distance, the covering rocks allow the complete sofening of the beds. Mining from the brook by a short tunnel (northward). Breast of say 200 yards. Total of soft ore, 580,000 tons.

Below brook water level (in the other direction, southwards and downwards) another 580,000 tons of soft ore, or even a larger quantity, is available.

(*f.*) Along the crop, in the curving valley bottom of the (northern) brook (north of the ridge and against the mountain), 2,800 yards to the end of Dutch Corner. Ore all below water level. Dip steep towards the east end. Extent of softening say 40 yards down. Total of soft ore, 250,000 tons.

Soft ore above water level, one million one hundred and twenty thousand tons.....1,120,000
Soft ore below level, one million six hundred thousand tons....1,600,000

Soft ore parts of the bed only.....2,720,000

It is unnecessary to calculate the quantities of harder ore in the undecomposed parts of the beds, amounting to millions of tons, for these will remain as a reserve for the future. The regularity of this ore formation enables one to assert that there lie six million (6,000,000) tons of ore, more or less, under every square mile of the district, where the dip is gentle.

No account is here taken of the ten miles of vertical beds from Dutch Corner to Bedford, and the vertical run of the beds for some miles north of St. Clairsville along the west side of Dunning's Mountain, towards Sarah Furnace, on the way to McKee's Gap.

A railway line up Dunning's Creek from Bedford to Holidaysburg (or McKee's Gap) will bring into play this long outcrop (north of St. Clairs-

ville), and there can be little doubt that mining operations will be successful at certain points along the outcrop.

It is well to remember the ore bed at the bottom of the red shale formation of No. V, the outcrop of which ought to be found still higher up the slope of Dunning Mountain, close to the uppermost stratum of the Middle Silurian White Sandrock of No. IV. Between Marklesburg and Saxton this bed (part rock ore and part soft fossil) is more than 20 feet thick, and is mined, yielding from 2 to 6 feet of soft ore.

Method of Mining.—Mr. Harden describes his views of the locality thus: In the several sections of the measures taken at the various openings and points of exposure we have conditions exceptionably favorable to the working of the less inclined portions of the belt, by open quarrying, and a personal examination made of the two tunnel openings of the Kemble Iron Company at Bedford Gap discovered nothing to me likely to conduce to an unfavorable condition for the mining of the more highly inclined and heavier covered portions of it. On the contrary, a somewhat extended practice in the mining of such like measures leads me to the conclusion, that, in the exercise of the skill necessary to all such work, the mining of these ores will not be productive of more than the average of ordinary difficulty, and as compared with the mining of the unstratified ores, will certainly be less, the cost of production also bearing relation thereto; always providing that the ores maintain their aggregate thickness and their average distance one from the other. And since the sections exhibited were taken at points extending ever an area of several miles, we are not led to expect a greater variableness than represent the sections themselves.

Hand specimens of the ore brought away gave a specific gravity of 2,818, a little more than that of the sandstone by which it is accompanied. This gives 175.62 lbs, per cube foot or 12.75 cubic feet to the ton.

From these data the production of ore will be 284 tons per inch per acre; which multiply by the number of inches thick in any given section and we have the total in tons per acre of the locality to which the section applies. Average the whole, say at 36 inches, and we get 10,224 tons per acre over the area covered.

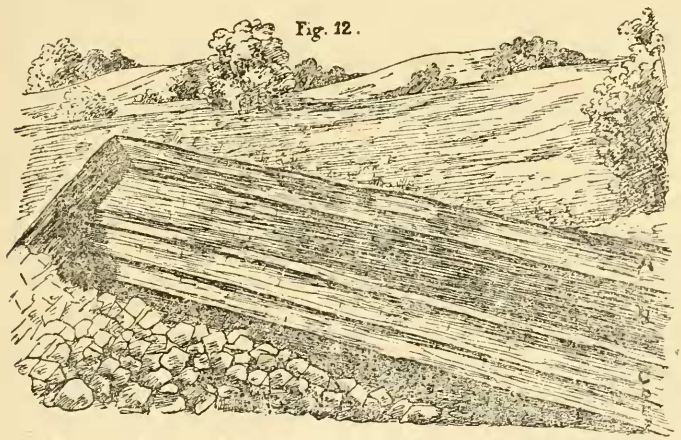
Presuming that those localities hold the beds easiest gotten will be the first to be attacked, a word on open quarrying will not be out of place. Stripping the ore, that is, taking off the surface covering, will necessarily be the first operation, and in doing this the dirt should not be dumped where it is likely to be in the way of future operations. This is not a needless warning. There is not an opening with which I am acquainted, unless lately made, that is not suffering more or less by being hampered up with old stripping, and where, in more than one instance, it has not had to be moved a second time.

Mr. Walters says that the greatest depth of covering on his farm, and at the explorations made in the neighborhood of it, is 6 feet to the top

band of ore. Call it 6 feet, add the 10 or 12 feet of measures to the bottom of the lower band, as represented in the section taken north of his house, and again in Dutch Corner, and we have a total depth of 17 feet. A length of bank-face should be set out, limited only by boundary lines, deviations in level, or quantity to be supplied, and this face should be quarried in widths, strip after strip from end to end, advancing up hill as rapidly as dictated by the demand, dumping the stripping and quarried refuse upon the cleared out ground, far enough away not to stifle the work to be done along the bank-face.

Seeking the width of strip best adapted to the result aimed at, and under certain conditions using gunpowder, the line of least resistance will fix that width; and as it is a heaving in mass that is contemplated, and not a blowing to pieces, the shots would be put to the bottom of the lowest band of ore. Eleven feet, then, would be the length of the line of least resistance, and the width of strip taken at one time not less. The sketch below, made from a section taken on Walter's farm and showing the three bands of ore, will help to convey the intention. Fig. 12.

Fig. 12.



SKETCH OF BANK-FACE WITH THE STRIPPING OFF TO THE FIRST BAND OF ORE.

A. Face of stripping, 6 feet thick.
B. Surface of Top Band Ore, 11 feet width of strip, 24 inches thick.
C. Interval of Shales and Sandstone, 42 inches.
D. Middle Band of Ore, 12 inches.
E. Interval of Shales and Sandstones, 36 inches.
F. Bottom Band of Ore, 13 inches.

Depth of Ore face with 2 intervals, 10 feet 7 inches, include Stripping, 16 feet 7 inches.

But as the ore to be taken out constitutes in bulk only a fourth of that to be quarried, and as when loose the refuse will occupy one and a half

times the space it did in the solid, it follows that the refuse heap will increase beyond the limits of the area quarried; this, however, is provided for in the rise of the hill as the work advances. Retaining walls will also be needed, from which to dump the ore into the railroad cars; these will be made of posts and planks backed up with the refuse.

The lay of the measures as a whole and their individual structure are each of a character favorable to such a mode of procedure. The jointed condition of the sandstone, when not in thin plates, will allow the free use of the crow-bar to advantage, but the shales operated on from above, that is, perpendicular to their bedding, will be tough to the pick-axe; holed under, or worked at on the face will give the best result.

While it may not be absolutely necessary to resort to blasting, a judicious use of gunpowder will be of great advantage. A series of holes put down to the bottom of the ore, or to the bottom of the lower interval, at a foot from face of stripping, and loaded so as to loosen the mass only, would make easier work for the crow-bar and pick-axe, and would not make the ore any the less easy of separation from the refuse. Each quarryman has generally his own notion of the quantity of powder to be used in a given case, seldom deduced from any fixed data. Practice has shown that the quantity must be increased as the cube of the mass to be blasted; from which it is laid down that the cube of the line of least resistance in feet, divided by two, equals the necessary quantity in ounces; less, however, will answer the purpose here; well directed experiment at the beginning will guide the application of the rule.

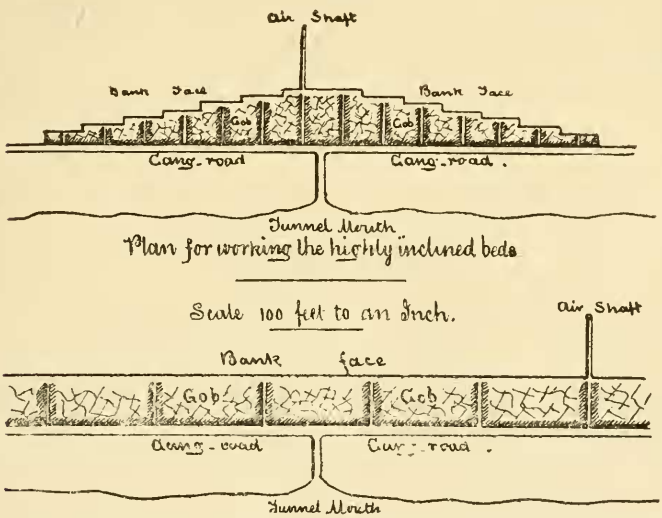
In estimating the cost of quarrying these ore beds, we have tolerably well-defined data in the ores and intervening strata, but a fluctuating element in the amount of covering. Taking, however, as an example the section before given, I am of opinion that at the present rate of wages, the ore may be put into cars on the quarry for—in other words, that the cost of production will be—one dollar twenty-five cents per ton ($1.25). With a less thickness of ore or increased covering the cost of production will be increased; 36 inches of ore, the average estimated, with the same amount of covering, will cost one dollar fifty-four cents ($1.54).

In the more highly inclined and heavier covered beds, we have conditions which render mining necessary, and the method I would adopt would be that which, in coal and the clay ironstone bands, is called Longwall; for whether mined in shorter or longer "banks," called by some "stoops," the same principle prevails, namely, that of mining out the whole of the mineral, packing the refuse gob or goaf, in the space mined, and putting out the ore either by shoots or cars, agreeable to the angle of inclination at which the measures lie.

With such inclinations as wherein cars cannot be made use of in the gob roads, a drift (tunnel) will be put in above water-level, and along the strike of the ore, of sufficient capacity for the running of cars, say 7 feet wide at the floor, battering inward to 5 feet at the roof, and 6 feet

or 6 feet 6 inches high, regulated by the height of the cars used; a shoot by which to deliver the ore into them to be provided. This gang road should have a series of "bolt holes" (places of refuge) cut for men to escape into when meeting the cars, and it will be necessary to well timber this road, the dimensions given being those clear of the timbers. On the rise side an opening head will be made parallel and immediately contiguous to it, both being extended just so far as it is intended to work the ore, it may be 1,000 or any number of feet regulated by the nature and the local uniformity of the measures, and the limit of economy in haulage and ventilation. The mouth of the gang road may either be at one end of the work, or it may be in the centre of it, receiving cars from right and left.

The opening head, as it is driven, will be divided into "banks" of say 35 or 40 feet long on the face, which banks will be mined to the rise, the ore being put down a road left in the centre by the gob being built up on either side, and supporting the roof, as shown in the diagram below. Ventilation being provided for by staples (small shafts) being



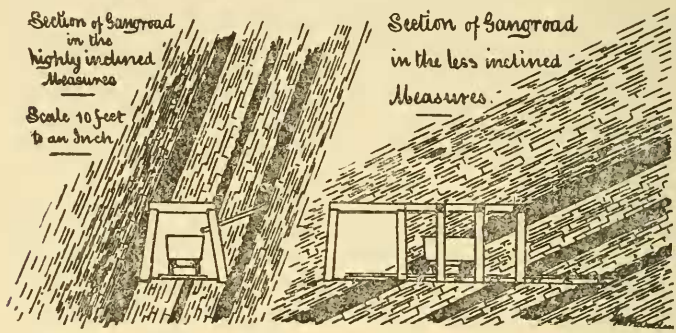
sunk from the surface, or by drifts put up in the ore; when that does not crop out on the surface, both will be needed.

With dips of less inclination, wider banks may be worked, the ore being run to the gang road by self-acting inclines.

While it is not easy to define beforehand with preciseness, what will be the action of any group of strata, the foregoing is a general description of the methods I believe best to be adopted in the mining of these ores. Of necessity contingencies will present themselves, which can only be

dealt with as they arise, but in the hands of a skillful and careful manager, I know of nothing likely to lead to unfavorable results, and I am of

Plan for working the less inclined beds.



opinion that, the ores, maintaining their thickness, will be mined and put into railroad cars at the mouth of the mine for two dollars and twenty-five cents ($2.25) per ton.

Stated Meeting, March 21st, 1873.

Present, 18 members.

Vice-President, Mr. FRALEY, in the Chair.

Letters were received from the Linnean Society, dated London (Burlington House, Piccadilly), August 15th, 1872, acknowledging the receipt of Transactions A. P. S. XIV, i, iii (requesting ii), and Proceedings 83 to 87, also transmitting publications of that Society, and from the Boston Public Library, acknowledging the receipt of No. 89.

A letter was read from W. A. Mansell & Co., 2 Percy Street, Rathbone Place, W. London, February 25th 1873, requesting the Society to purchase a copy of the Series of Photographs of the British Museum.

Donations for the Library were announced from the R. Prussian Academy, Mr. Robert Grassmann, of Stettin, the